

Space Geodesy Facility (SGF)

Interim report to NERC Space Geodesy Facilities Steering Committee, 2006
May to November.

1. Introduction

This report lists the main achievements at SGF since the Operational and Annual Reports were presented to NSGFSC in 2006 June. It outlines work on the laser ranging, GNSS, Gravimeter and LIDAR programmes and reports on some international activities of relevance.

2. Satellite Laser Ranging

- a. **'Standard' SLR activities.** The summer months were extremely productive, with good tracking coverage from Herstmonceux of all the ILRS and NSGFSC priority targets. A GIOVE-A campaign was organised by ESA starting in June, and a reasonable quantity of data was obtained to support GIOVE-A clock characterisation, as detailed in an ESA report at:
http://www.esa.int/esaNA/SEM8QOKKKSE_index_0.html and the *Inside GNSS* report from SGF at <http://ilrs.gsfc.nasa.gov/docs/IG0606-appleby-v2GG2.pdf>
- b. **Progress towards kHz rate ranging.** The final piece of hardware needed to complete this programme, a precise and accurate event timer (HET), which was assembled in-house, was completed during August. A great deal of software development and hardware tweaks then integrated the timer into the existing operational system and permitted a re-calibration of the pre-HET measurements over the entire range of a few metres for the local calibration targets out to 23,000 km for GIOVE-A. This re-calibration exercise proved extremely useful in characterising the non-linear behaviour of the existing Stanford counters at the short ranges to the local targets, and showed that all SGF satellite ranges over the period 1994 to date are short by 8 ± 2 mm. In the context of the SLR technique being used to define the origin and scale of the TRF, this is a large error and will be taken into account when the data are re-analysed for TRF studies. This result and its estimated effect on the TRF coordinates of Herstmonceux was presented at the Laser Ranging Workshop in Canberra in October. A paper by Gibbs *et al* will appear in the proceedings in spring 2007. The HET in place, rapid progress was made to achieve experimental laser ranging at 2,000 shots per second, with ranges to all the major satellites obtained by early October. As an experimental system, not all the safety interlocks, to radar, to eye-safe shutter and manual cut-out were in place, so observations were carried out by three members of staff to cover manually these safety elements of the system. During November the radar and manual interrupts have been fully integrated and work is in hand to include the automatic eye-safe control for calibration ranging. A paper on kHz ranging at Herstmonceux was presented in Canberra, and a comprehensive paper will appear in the proceedings. Some details of the ranging including realtime plots are available on the SGF website at <http://nercslr.nmt.ac.uk/khz/khz.html> Work continues to develop a robust pre-processing system that will not insert a discontinuity into the Herstmonceux data except, of course, that the previous range bias will disappear once the HET is in routine

use at a date to be determined and announced to the community. It will also be necessary to develop a camera system to view the fainter kHz backscatter during daytime to optimize pointing, and engineering plans are well advanced.

- c. **Local Target.** Range observations using the HET to the in-dome calibration target provide for the first time, and at a level of accuracy of 1mm, an independent check on the standard range calibration value derived from the external calibration target. Non-linearities present in the Stanford counters had previously confused this issue, despite our confidence in the survey (OS and UCL) distance to the external target. In addition, a new laser calibration target has been installed 200m south of the Facility on an ex Met-Office tower. A survey will be required to link this target into the local frame.
- d. **Global SLR Network.** The NASA systems at Arequipa, Peru and at Haleakala, Maui, Hawaii, are both back in operation after two-year closures. A new Russian system at the Baikanour satellite launch site is now operational, as plans to develop a significant number of new stations over the next few years continue.
- e. **Analysis.** The SATAN analysis package has been updated to include the improved tropospheric delay model of Mendes and Pavlis and a new implementation of ocean loading as recommended by the IERS. Automated weekly solutions continue to be submitted to the ILRS combination centres.
- f. **Photometric observations.** The laser ranging tracking system was used by request from MoD to monitor reflected sunlight variations from several satellites. The observations were reduced and communicated to MoD as short reports.

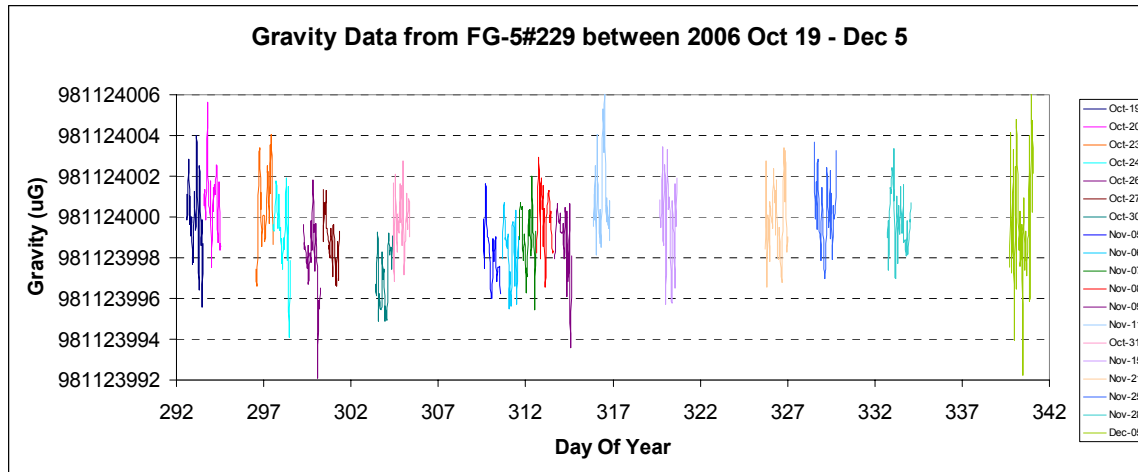
3. GNSS.

- a. **Tracking.** HERS and HERT continue in routine continuous operation, with HERT also configured for Internet streaming in support of the expanding EUREF real-time GNSS over Internet Pilot Project. More worrying was the apparent lack of use within IGS analyses centres of these systems for routine daily ITRF and EOP work, despite their current demonstrably good performance. However, a recent communication from the IGS does show that at least two IGS ACs are currently analysing data from both systems.
- b. **Analysis.** Daily automatic analysis of a subset of the global stations continues, with the emphasis on results for a local network including a station in Eastbourne via the BIGF archive. Special L2-only treatment of the HERS-HERT baseline reveals seasonal relative motion of amplitude 2mm, the cause of which is under investigation. Results are posted daily on the SGF web at http://nercslr.nmt.ac.uk/gnss/gps_sgf.html We plan a paper on this local stability work, in part to address the issue discussed in a). M. Wilkinson attended a useful hands-on two-day GAMIT workshop in Luxembourg in November and wrote a short trip report.

4. Gravimetry

- a. **Absolute Gravimeter.** Since the 19th of October the AG has been fully operational in its basement laboratory. In the 2006 Steering Committee Report it was stated that electrical problems had been found and these continued throughout the summer whilst possible causes were worked through. The fault was finally agreed to be a problem with the Serial Interface Module in the electronics control rack. Subsequently the manufacturers Micro-g LaCoste replaced this module under warranty during October.

After this date a period of intensive measurements was carried out over a three-week interval. Since the 21st of November the current measurement campaign has been running using weekly 32-34-hour projects centered on mid-GPS-week. An example of the hourly mean-value results is shown in the plot below.



Note that the RMS of the December 5th project was exceedingly high, thought to be due to the storm force weather. Daily mean values have 1-sigma standard errors of about 1 μ gal, equivalent to a height change sensitivity of better than 5mm.

- b. Training.** V Smith attended a weeklong advanced AG operations course at Micro-g LaCoste premises in Boulder in September and wrote a trip report upon her return. She continues post-graduate studies at UCL, in association with POL.
- c. Survey.** OS spent two days on site in July carrying out a valuable survey to tie the AG stud markers into the local network, and included the location of the borehole reference point. OS carried out the survey at no charge, as their contribution to the European Coordinated Gravimetric Network programme. We are extremely grateful to OS for this work.

5. LIDAR

- a. Existing data.** Analysis of historical global laser data yield continues, in collaboration with R Jones at Cambridge University. It's hoped the data yield is a proxy for atmospheric transparency, and some interesting signatures are present for several of the ILRS stations.
- b. SGF data.** Improvements have been made to the collection and analysis software for the Herstmonceux backscatter observations, including estimation of atmospheric scale and boundary heights from the data. Laser ranging through aircraft contrails also looks to be a promising and novel way of estimating their optical densities and will be pursued. A poster presentation on this work was well received at the Canberra ILRS workshop.

6. Infrastructure

- a. Computer LAN.** The current LAN is showing signs of aging, and its multi-epoch Ethernet systems are likely responsible for observed 'bottleneck' effects. R Sherwood

in consultation with ITSS is working on a costed proposal to upgrade the network. The upgrade will include facilities ultimately to host the SGF website, which is currently managed at Monks Wood.

- b. Meeting Room.** Shortly after the June meeting of NSGFSC in the new basement room, a large water leak was discovered in the ceiling. The contractors have carried out several repair attempts, but the problem remains to be resolved. Pressure on the contractors from NERC Estates Management has now forced a site meeting for all parties, and we expect an early resolution of the problem.
- c. Greening.** Several suggestions to conserve energy on site have been put to the NERC Greening initiative. The proposals primarily involve insulation of the main building to reduce work required of the air-conditioning plants and insulation of the offices to conserve heating energy.
- d. Funding.** MoD funding for 2005/06 has been received. BNSC have yet formally to commit.
- e. Forward Look.** A five year FL of proposals for short, medium and long-term developments for SGF is currently being developed. A draft will be available in early 2007.

7. ILRS workshop in Australia.

- a. Papers presented.** G Appleby and P Gibbs attended the 15th International Workshop in Canberra and presented papers on kHz ranging, a reassessment of SGF range accuracy and a poster on the new LIDAR work. Various working groups were contributed to and attended, Gibbs primarily the Network and Engineering WG on counter calibration and Appleby the Analysis WG on TRF solutions. Trip reports have been written.
- b. Highlights.** Of interest was a session on ‘Transponders’ when a NASA group discussed the Lunar Reconnaissance Orbiter due for launch in 2008 to map the surface of the moon. As part of its precise tracking it will utilise one-way laser ranging from the Earth. The ‘old’ SGF laser may well meet the required specifications on power and repetition rate, and we expressed strong interest in being involved. Time transfer by laser ranging is also an emerging application, the next major opportunity being a system on the JASON-2 altimeter mission due in 2008. A French group is coordinating the time transfer project, but SGF involvement would only be of value if we had access to high accuracy time, such as via a H-maser clock, ideally in collaboration with a time standard laboratory. An interesting possibility to test time transfer was proposed by colleagues at NICT, to use AJISAI’s mirrors to reflect time-tagged pulses emitted from one station for reception by another. Candidate stations for this experiment would be the kHz stations at Graz and SGF. An update on the Russian GLONASS programme was given during the General Assembly: it is expected that 18 vehicles will be operational by the end of 2007 and 24 by the end of 2009. By the year 2010 the system should be comparable to the GPS and GALILEO systems.

SGF 2006 December.